ADVANCED TELEVISION RESEARCH ACTIVITIES AT CABLELABS

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Abstract

The broadcast and cable television industries in North America are on the threshold of a new era. Seven organizations are competing to have their advanced television system concepts adopted as North American standards for transmission of either High Definition Television (HDTV) or for emission of improved or extended definition NTSC to consumers' homes. This paper will describe overall activities in this area, as well as CableLabs' preparations to conduct the rigorous technical tests of these systems that will be needed to protect the cable industry's interests in the era of advanced television. CableLabs is also embarking upon efforts to further the development of digital transmission of compressed NTSC signals over cable systems, a capability now widely recognized as having major strategic importance to the continued growth of our industry.

Worldwide, there are two main areas of HDTV development underway. First, there is the activity targeted at developing a worldwide production standard, or at least a family of related standards, for the production of high definition television programming. This has been going on in earnest for about eight years.

Second, there are the more recent efforts, to develop transmission systems to get those advanced pictures to the home. Obviously, cable operators are most interested in the latter, and it is this activity that will be reviewed in this paper. I will also describe CableLabs' activities to coordinate development of the technology for the digital transmission of compressed NTSC over existing and future cable television systems.

The ATV Proponents

When it comes to transmission via cable and over-the-air broadcast, there are six independent organizations which are formally proposing systems for for adoption as an FCC standard for the United States.

They include systems from NHK (Japan Broadcasting), Philips Laboratories, MIT, Zenith, General Instrument, and the David Sarnoff Research Center.

There is also the SuperNTSC™ system from Faroudja Research Enterprises – an improved NTSC system that in 1990 was withdrawn from the formal FCC standardization process in the belief by its developer that it can be commercialized without FCC approval.

Some of these transmission systems are still being designed – some in fact are being recently redesigned as all-digital systems. CableLabs will conduct laboratory and field testing of these systems, with lab tests to begin in April 1991 and to finish during the second quarter of 1992.

The Market for Advanced Television

Whatever the outcome of those tests and the standardization to follow, the best estimates are that advanced television will happen slowly, with startup service during this decade, but at relatively low consumer receiver penetration. Beyond the year 2000, though, most observers expect major penetration of advanced television, and an eventual, total replacement of NTSC perhaps twenty-five or thirty years from now.

What Cable Must Do

For now, cable must make efforts to forward the interests of the industry and of our subscribers. We are the delivery mechanism for well over half the households in the U.S., and we need to influence the design of this soon-to-be-standardized advanced television system so that it works well over cable systems. The ATV system needs to take into account cable's particular set of transmission impairments, which are quite different from those of the over-the-air broadcast path.

Finally, we must prepare our cable systems, with respect to the quality of our channels and to the channel capacity of our systems, in order to be ready for the the era of Advanced Television.

If we are successful, we will be able to carry high quality ATV services with a minimum of disruption and difficulty, at minimum cost. On the more positive side, a redesign of the basic television signal carried on our systems may well improve the way cable systems operate, and will likely allow some new revenue opportunities.

The ATV Alphabet Soup

A review of some of the common acronyms in the advanced television field would be useful at this point:

ATV, of course, is a general term applied to almost any form of consumer television that is a step beyond NTSC (or PAL or SECAM, for that matter). There are a range of advanced television technologies: IDTV, EDTV and HDTV are the primary terms being used. The definitions I am about to review are in line with those formally agreed upon by the Advanced Television Systems Committee, and are therefore becoming standardized.

IDTV, or Improved Definition Television, refers to improvements to NTSC television which remain within the general parameters of NTSC emission standards and, as such, would require little or no FCC action to implement. Improvements may be made at the source and/or at the television receiver and may include improvements in encoding, filtering, ghost cancellation, and other parameters as long as what is transmitted and received qualifies technically as standard NTSC in a 4:3 aspect ratio. Faroudja's SuperNTSC™ claims to fall into this category.

At the moment, though, improved definition television has not been implemented by changes in processing at the transmission end. Practically then, IDTV today means a receiver that is specially equipped to process a normal television signal. These receivers generally reduce NTSC color artifacts via three dimensional comb filtering for separation of luminance and chrominance; they generally provide some video noise reduction; and, most obviously, they all double the number of scan lines appearing on the display tube.

Line doubling generally involves displaying 525 lines, progressively scanned; that is, 525 lines, every 1/60th of a second, as opposed to NTSC's 262.5 lines per 1/60th of a second. This reduces the visibility of the scan-line structure of the NTSC signal, and improves apparent vertical resolution, although there is actually no additional picture information being presented. (In the case of the Faroudja SuperNTSC™ system, line doubling creates a 1,050-line interlace-scan picture.)

Some estimates say that to date, only about 5,000 of the current-design IDTV receivers have been sold in the United States. They tend to have list prices in the $1,800 to $3,000 range for direct-view CRT models and come with their own set of

picture artifacts along with their improvements. They are available from Philips, Sony, NEC, Panasonic, Hitachi and a few other major manufacturers. These IDTV receivers represent a transitional technology between today's NTSC and the true improved, extended or high definition television systems that we'll see in a few years.

EDTV, or Extended Definition Television, refers to a number of different improvements that modify NTSC emissions, but that retain NTSC receiver-compatibility.

In other words, additional picture information is inserted into the 6-MHz channel which will not disturb an existing NTSC receiver, but which can be decoded by an EDTV receiver and used to display an improved picture. These changes may include a wide screen image (16:9 aspect ratio vs. NTSC's 4:3 image), and some modest extension of resolution, to a level somewhat less than twice the horizontal and vertical resolution of standard NTSC. Digital sound is generally a feature of EDTV systems.

The David Sarnoff Research Center is preparing an EDTV system called ACTV, or Advanced Compatible Television. This system will be the first to be tested under the auspices of the FCC Advisory Committee on Advanced Television Service.

Finally, HDTV, or High Definition Television, refers to television systems with approximately twice the horizontal and vertical emitted resolution of standard NTSC and improved color rendition. HDTV systems are wide-aspect ratio systems, and they generally attempt to approximate the picture quality of projected 35mm motion picture film. They are designed to be watched on large screens, where the NTSC system has historically failed to please. Digital sound is being planned by all proponents of HDTV systems.

"Compatibility" and the Role of "Simulcasting"

By FCC ruling, HDTV systems must not obsolete existing NTSC receivers, and can avoid doing so in one of two ways: they can be truly receiver-compatible, although this appears to be an impossible constraint while fully delivering NTSC horizontal and vertical resolution twice. Alternately, they can simulcast, on a completely separate RF channel, a newly-designed, non-compatible HDTV signal.

It is this simulcast architecture that has been selected for standardization by the FCC, because it promises to deliver the highest quality of service to American homes. Simulcast transmission systems are being worked on by five separate transmission system proponents, as mentioned earlier: NHK, Zenith, General Instrument, MIT and Philips. The Commission has indicated it will not consider setting a standard for EDTV until it has selected a simulcast HDTV standard, if at all.

Given the FCC's preference for the simulcast approach, let's review it in some detail. Under this approach, HDTV program services would have to be broadcast simultaneously with their sister NTSC services, so that the existing NTSC receivers are not made useless. The Commission has ruled that the spectrum for these new channels will be found within the existing VHF and UHF bands. The obvious implication for broadcasters is that each television station may be allocated an additional channel for its simulcast HDTV service, and indeed there seems to be a possibility to attain something close to this. Thus, cable operators may someday see the need to literally double their capacity for broadcast channels, and perhaps for many cable program services as well, if they decide to offer service in HDTV.

In the long term, as the simulcast system takes over, the NTSC channels can be discontinued, and the spectrum, or cable capacity, recovered for other uses. But there will certainly be a period of many years where cable systems will need the channel capacity to carry all the desired NTSC services and the new ATV simulcast services as well.

Interference Characteristics of ATV Signals A Critical Issue

Since the FCC's interests and power lie in regulating broadcasters and in allocating the over-the-air spectrum, it is the broadcasters' concerns that are dominating the development of ATV systems.

Fundamental to the success of any simulcast HDTV system will be its ability to successfully transmit its service without interfering with existing NTSC stations – either on the same channel in a nearby market, or on an adjacent or near-adjacent channel in the UHF band (the so-called "UHF taboos").

The approach being taken in some of the simulcast systems to solve these problems involves spreading the channels' transmission energy uniformly across the 6-MHz channel, and limiting peaks of power at particular frequencies or at particular points in time. If these techniques prove successful in lab and field testing, spectrum can probably be found for the broadcasters, and introducing ATV signals on cable will be made very much less technically demanding.

Business Issues in Advanced Television

Beyond these transmission parameters, the business realities of the cable industry will impose additional requirements on ATV systems: We will need a seamless interface to consumer equipment to avoid the difficulties we now put our customers through and to avoid cable operators' investment in set-top converter/descrambling devices. There is time to plan this properly, if the cable industry makes its voice heard.

The subscription pay business and the pay-per-view prospects of advanced television are staggering, but only if we make sure the adopted system has conditional access capability built in from the start. This conditional access, by the way, must be under the control of the individual cable operator who markets to his customer base and not merely under the control of the national programming provider.

Ghost cancelling is highly likely to be a standard feature of any ATV system, since multipath problems and microreflections, in the case of cable, are possibly ruinous to high resolution pictures. Whatever the ghost canceling scheme, it needs to work as well over cable systems as it does over the air.

Cable, of course, has unique requirements for data transmission to its subscribers' homes, and the ATV systems need to take our present and future needs into account.

Finally, ideally, the broadcast ATV system should be structured to allow cable operators to augment the normal 6-MHz channel with some additional spectrum to provide a higher performance level, primarily, better picture resolution, and better motion rendition. We may need this capability to compete with home video media and DBS transmission of very high quality HDTV.

Beyond these basic capabilities, any ATV system will need to meet cable's economics for production; its satellite interconnection practices;

its headend design considerations; and ideally be able to survive its customary distribution practices, including FM supertrunking, AML systems, fiber links, and long cascades of trunk amplifiers, as well as the usual complement of feeder actives and passives.

Cable Industry Influence is Crucial

How to make sure the ATV system adopted meets these requirements? The answer is twofold: technical testing by CableLabs and participation by the cable industry in the deliberations of the FCC Advisory Committee on Advanced Television Service.

First, as I've mentioned, on behalf of our member companies, CableLabs will be conducting a series of tests on each of the proposed ATV transmission systems.

CableLabs' ATV Testing Program

Under a $2.5 million contract with the broadcasters' Advanced Television Test Center (ATTC) in Alexandria, Virginia, we will conduct cable transmission simulations with a test bed of our own design, operated by CableLabs' personnel, and according to test procedures developed by CableLabs and approved by the FCC Advisory Committee on Advanced Television Service.

An Overview of the ATV Testing Program

But to put the CableLabs tests in context, let me back up for a few moments to review the entire testing process.

Three Test Types - Three Test Sites

Overall, the ATV testing is a North American effort that will take place in a total of three venues:

- at the American broadcasters' laboratory, the ATTC, where basic picture quality will be tested along with simulated over-the-air impairments and interferences,

- at the CableLabs facility, where each ATV system will be tested under various conditions of cable transmission impairment,

- and at the facilities of the Advanced Television Evaluation Laboratory, in Ottawa, Canada. This subjective test operation will be operated by the Communications Research Center of the Canadian Department of Communications. A consortium of Canadian interests is sponsoring CRC's conduct of the subjective assessments of quality and transmission performance.

Basic Quality Tests

The ATTC will perform the basic picture quality tests in which both broadcasters and cable operators have a vital interest. These are evaluations of the picture quality that each ATV system is ultimately capable of, assuming an ideal transmission path. Test signals and pictures will be encoded by the ATV system's encoder, which in all cases involves some bandwidth compression processing, then modulated to RF, and finally demodulated for display on a high definition video monitor.

Quality attributes to be evaluated include luminance and color resolution, color rendition and motion rendition. Also to be evaluated will be performance with filmed program material and with electronic graphics material, each of which presents its own technical characteristics and potential problems.

The proponent systems' basic picture quality will vary depending upon the wisdom of the

designers' choices of basic scanning format and bandwidth reduction and restoration techniques.

Impairment and Interference Tests

Certainly as important as the systems' basic picture quality is their performance in the face of transmission impairments and interferences.

Impairment/Interference Tests - Broadcast

As I've indicated, benign interference performance, in particular, will be of pivotal importance to selection of an ATV system that is practical in today's crowded over-the-air spectrum.

Broadcasters will test transmission performance in the face of various impairments, including random noise, impulse noise, multipath effects, and airplane flutter.

Broadcast interferences to be tested include co-channel and adjacent-channel interference, UHF taboo channel interference, and discrete frequency interference.

Impairment Tests - Cable

CableLabs will conduct tests of at least eight typical transmission impairments common to cable television distribution systems. Testing of the first system is currently planned to begin in April 1991. Testing of each system is expected to take a total of eight to 10 weeks in the broadcast and cable laboratories, and an additional period of perhaps six weeks for subjective testing in the Canadian laboratory, which will run concurrent to the lab testing of the next ATV system. Lab testing of the six systems should be completed by the end of April 1992.

Field testing will follow in the second and third quarters of 1992 according to procedures currently being developed by the FCC Advisory Committee. The Committee's final report and standards recommendation to the FCC is due by the close of the third quarter of 1992. The Commission plans to make its standards decision on a simulcast system during the second quarter of 1993.

Although HDTV may grow slowly in the marketplace, the next two and one-half years will involve intensive planning and decision making. The cable industry's considerable engineering and management talent needs to participate in the planning and deliberations of the FCC Advisory Committee on Advanced Television Service if we are to have an ATV system that meets cable's needs. I urge each of your companies to send representatives to these meetings and make your views known.

Digital Transmission and NTSC Compression

Just how cable might implement the digital transmission of compressed NTSC signals on its existing and future plants is perhaps a hotter topic than HDTV. CableLabs is studying these issues from both business and technical perspectives.

There are some enormous strategic implications in this topic:

- Digital transmission of NTSC offers the promise of uniformly high quality video and audio in each subscriber's home, regardless of the distance from the headend or the age or condition of the cable plant.

- Compression of NTSC signals (which in any case is needed to fit a single digital NTSC signal into today's 6-MHz cable channel) offers the promise of transmitting more than one NTSC

program in each channel — perhaps two, three, or four programs simultaneously on a full-time basis.

Video compression's cost and complexity need to be traded off against the raw upgrading of a cable system's overall bandwidth. Bringing fiber optic cabling close to subscribers' homes, coupled with new wider-bandwidth RF amplifiers, can achieve increases in channel capacity in very cost effective ways. To be successful, video compression of NTSC will need to be low in cost.

As CableLabs investigates NTSC compression technolgies, we believe that any system ultimately deployed must provide a quality level that is at least as good, subjectively, as the best current analog NTSC transmission via cable. There is no reason to expect that viewers would, or should, tolerate a decline in delivered quality. Ideally, the usage of an NTSC compression system in a cable system should be both technically and functionally transparent. The goal is to provide new programming, and to provide it in a more flexible manner – not to "thrill" subscribers with new technology.

CableLabs' Technical Advisory Committee has formed a Subcommittee on Video Compression to study the issue of NTSC compression over the satellites that feed cable systems and over the cable plants themselves. This committee is chaired by Ed Horowitz, Viacom's Senior Vice President of Technology. The committee meets regularly with the staff of the Advanced Television Projects Department at CableLabs and with vendors proposing compression and transmission technology for use by the cable industry.

Whatever NTSC compression system is identified for use on cable, it is clear that the resulting signal will be a digital signal. Transmission of high-rate digital signals with low error rates over cable systems is a new field which requires research. CableLabs will conduct a series of digital transmission tests over laboratory simulators and real-world cable plants to determine exactly what modulation schemes will support what bit rates. This early research, much of which will be completed by CableLabs ATV staff this year, will give us a fundamental reading of cable systems' digital transmission capabilities. Pursuit of a particular digital transmission protocol and the compression system it carries will flow from this basic understanding.

In summary, we believe that the cable industry's twin interests in the future of television are in good hands. CableLabs is a key player in testing of the proposed HDTV and EDTV systems, and intends to lead the development of a digital transmission architecture for transmission of HDTV and compressed NTSC services as well.